

LOGICAL VALIDITY AND ABDUCTIVE REASONING IN THE AGE OF ARTIFICIAL INTELLIGENCE: A PHILOSOPHICAL-LOGICAL ANALYSIS

Otajonov Gayratjon Umarovich
Teacher of Philosophy, Kokand University

Abstract

The article analyses logical validity, abductive reasoning and epistemic responsibility in the contemporary digital environment. It reconstructs the relationship between classical formal logic, theories of scientific explanation and decision-making practices in artificial intelligence systems. The study argues that logic should not be reduced to a technique of formally correct inference; it must also be understood as an intellectual infrastructure that secures trust, explainability and responsibility in digital society. The proposed philosophical-logical model clarifies the limits of algorithmic inference and defines the normative role of human judgement.

Keywords: Logic, abduction, artificial intelligence, epistemic responsibility, philosophy, argumentation, digital reasoning.

Introduction

Annotatsiya. Maqolada zamonaviy raqamli muhitda mantiqiy haqiqiylik, abduktiv xulosa va epistemik mas'uliyat masalalari falsafiy-mantiqiy nuqtai nazardan tahlil qilinadi. Tadqiqot klassik formal mantiq, ilmiy tushuntirish nazariyasi va sun'iy intellekt tizimlarida qaror qabul qilish amaliyotlari o'rtasidagi murakkab aloqani ochib beradi. Natijada mantiqni faqat to'g'ri xulosa chiqarish texnikasi emas, balki raqamli jamiyatda ishonch, izohlanish va javobgarlikni ta'minlaydigan intellektual infratuzilma sifatida talqin qilish zarurligi asoslanadi.

Kalit so'zlar: mantiq, abduksiya, sun'iy intellekt, epistemik mas'uliyat, falsafa, dalillash, raqamli tafakkur.

Аннотация

В статье рассматриваются логическая валидность, абдуктивное рассуждение и эпистемическая ответственность в современной цифровой среде. На основе философско-логического анализа раскрывается связь между классической формальной логикой, теориями научного объяснения и практиками принятия решений в системах искусственного интеллекта. Обосновывается тезис о том, что

логика должна пониматься не только как техника корректного вывода, но и как интеллектуальная инфраструктура доверия, объяснимости и ответственности в цифровом обществе.

Ключевые слова: логика, абдукция, искусственный интеллект, эпистемическая ответственность, философия, аргументация, цифровое мышление.

INTRODUCTION

The problem of logical validity has never been a merely technical question, because every historical transformation of rational culture has changed the social meaning of correct inference. In Aristotle's syllogistic tradition validity meant the necessary preservation of truth from premises to conclusion; in the modern symbolic tradition it became the formal relation between a set of propositions and what follows from them; in contemporary computational culture it is often confused with the output of a system that produces plausible, useful or statistically probable answers. This confusion is not innocent. In a world where scientific texts are searched by algorithms, legal opinions are filtered by automated tools, educational assessment is increasingly data-driven, and political communication is shaped by recommender systems, the difference between formal validity, empirical reliability, explanatory adequacy and institutional accountability becomes a question of public rationality. The present article proceeds from a simple but demanding thesis: artificial intelligence can assist inference, but it cannot by itself replace the philosophical normativity that makes inference rationally accountable. The urgency of this thesis is connected with the rise of generative and decision-support systems whose outputs are linguistically convincing yet not always logically warranted; such systems can imitate the grammar of reasoning without possessing the responsibility of a reasoner. The difference is crucial for philosophy and logic, because a conclusion may sound convincing, be probable within a data distribution, and still fail to be valid, relevant or justified. At the same time, a strictly deductive model is insufficient for most real scientific, educational and social decisions, since human inquiry regularly works with incomplete evidence, uncertain causes, competing explanations and practical constraints. This is why abductive reasoning, understood since Charles Sanders Peirce as inference to a plausible explanatory hypothesis, becomes one of the central categories for a philosophy of logic in the digital age. Abduction does not abolish validity; rather, it operates in those zones where validity must be supplemented by criteria of explanatory power, coherence, simplicity, fruitfulness, defeasibility and public testability. The philosophical task is therefore not to oppose formal logic and artificial intelligence mechanically, as if one belonged to pure reason and the other to mere machinery, but to determine the exact limits of their cooperation. Formal logic provides norms of consistency and consequence; probabilistic and computational systems provide patterns and predictive associations; abductive reasoning provides a bridge between observed data and explanatory hypotheses; epistemic responsibility

provides the human and institutional framework in which reasons can be challenged, revised and justified. Without this layered understanding, digital society risks replacing the question “Is the conclusion justified?” with the weaker question “Did the system produce it?” The article aims to reconstruct this problem at DSc-level theoretical depth by integrating formal-logical, epistemological, philosophy-of-science and applied digital-ethics perspectives. Its object is the transformation of logical reasoning under conditions of algorithmic mediation; its subject is the normative relation between validity, abduction and responsibility in artificial-intelligence-supported reasoning. The scientific novelty lies in proposing a three-level model of digital rationality: the level of logical validity, where conclusions are assessed according to rules of consequence; the level of abductive adequacy, where hypotheses are assessed according to their explanatory and heuristic value; and the level of epistemic responsibility, where human agents and institutions remain answerable for the use, interpretation and consequences of automated outputs. This model is important for higher education as well, especially for philosophy teachers, because the teaching of logic can no longer be limited to categorical syllogisms, truth tables or fallacy lists; it must prepare students to identify pseudo-reasoning in algorithmic environments, to distinguish validity from plausibility, and to cultivate an intellectual culture in which technology is used as an instrument rather than enthroned as an oracle. Logic, in this sense, is not a dusty museum of symbols; it is the traffic law of thinking, and without it the digital highway becomes a very expensive accident scene.

MATERIALS AND METHODS

The methodological basis of the article is a philosophical-logical reconstruction that combines comparative analysis, conceptual clarification, normative modelling and critical interpretation of contemporary artificial-intelligence discourse. The material of the study is not an experimental dataset in the narrow empirical sense, because the research belongs to theoretical philosophy and logic; however, it relies on a corpus of classical and contemporary sources that includes Aristotelian syllogistic theory, Fregean and Tarskian conceptions of formal validity and truth, Peircean accounts of abduction, twentieth-century theories of scientific explanation and argumentation, and recent normative frameworks on trustworthy artificial intelligence. The first method is historical-comparative analysis, through which the meanings of deduction, induction and abduction are distinguished in relation to their epistemic functions. Deduction is treated as truth-preserving inference under rules; induction as ampliative generalisation from observed cases; abduction as hypothesis formation directed toward explanation. This triadic distinction is not used mechanically, because real reasoning often combines all three, yet it allows the study to avoid the common error of measuring every digital output by a single standard. The second method is conceptual analysis, which clarifies the internal difference between validity, soundness, probability, reliability, explanatory relevance and responsibility. Validity is a formal relation; soundness requires true premises; probability

concerns degrees of expectation; reliability concerns repeated performance under relevant conditions; explanatory relevance concerns why a conclusion illuminates a problem; responsibility concerns who can answer for the selection, interpretation and use of reasons. The third method is normative modelling. Here the article constructs a three-level model of digital rationality in order to show how different criteria operate simultaneously in artificial-intelligence-supported inquiry. This modelling does not claim to replace existing technical risk frameworks; it philosophically interprets their deeper rational presuppositions. The fourth method is critical-hermeneutic interpretation of digital epistemic practices. This means that artificial intelligence is not analysed only as software but as a socio-technical practice embedded in education, governance, science, law and everyday communication. When a system produces an answer, the output is always interpreted by teachers, students, administrators, researchers, journalists or citizens. The interpretation is not external decoration; it is part of the epistemic event itself. A medical decision-support model, a legal search engine, a plagiarism detector, a recommendation algorithm and a generative model all involve inference, but none of them creates public justification by mere production of output. Therefore, the article adopts a human-centred epistemological stance: technologies may extend the range of available evidence, but responsibility for rational acceptance remains with persons and institutions. This stance is compatible with contemporary discussions of transparency, explainability and accountability, but it insists that those categories remain shallow unless connected with logic as a discipline of reasons. The procedure of analysis follows four stages. First, the article distinguishes validity from plausibility and identifies why algorithmic persuasion can simulate rationality. Second, it reconstructs abduction as the dominant inferential pattern of uncertain digital environments. Third, it analyses the risks produced when abductive hypotheses are presented as settled knowledge. Fourth, it formulates educational and institutional implications for the teaching of logic and philosophy. The methodological limitation of the study is that it does not test a particular AI model statistically; its contribution is conceptual and normative. This limitation is appropriate to the aim, because no amount of statistical testing can by itself answer the philosophical question of what makes an inference justified in a community of rational agents.

RESULTS

The first result of the study is the clarification that logical validity and algorithmic success belong to different normative orders. Logical validity concerns the structure of inference: if the premises are true and the rule is correctly applied, the conclusion cannot be false. Algorithmic success, by contrast, often concerns optimisation: the system produces outputs that correspond to training patterns, target metrics or user expectations. These two orders may cooperate, but they must not be identified. A search system can retrieve relevant texts without validating an argument; a generative system can produce a grammatically elegant paragraph without preserving truth; a predictive model can

estimate risk without explaining the normative meaning of risk; and a classifier can categorise data without justifying the conceptual boundaries of the categories used. The second result is the identification of abduction as the central inferential form of digital reasoning under uncertainty. In practical digital environments, agents rarely possess complete premises from which conclusions follow deductively. Instead, they encounter fragments of evidence, noisy data, conflicting signals and incomplete background theories. In such conditions, reasoning often proceeds by asking what hypothesis would best explain the observed pattern. This is the logic of diagnosis, scientific discovery, historical interpretation, forensic reconstruction, and many forms of policy analysis. Artificial intelligence amplifies this pattern because it can rapidly generate candidate explanations or associations; however, generation is not justification. An abductive hypothesis becomes rationally acceptable only when it is compared with alternatives, tested against evidence, evaluated for coherence with established knowledge, and kept open to revision. The third result is the formulation of a three-level model of digital rationality. The first level, logical validity, asks whether the transition from premises to conclusion follows accepted rules and whether contradictions, equivocations, hidden premises or fallacies are present. At this level, classical logic, propositional logic, predicate logic, modal logic and informal argument analysis remain indispensable. The second level, abductive adequacy, asks whether a hypothesis explains the relevant facts better than its competitors, whether it has empirical and conceptual economy, whether it opens new lines of inquiry, and whether it can be defeated by contrary evidence. At this level, philosophy of science, methodology and critical thinking meet. The third level, epistemic responsibility, asks who selected the premises, who defined the problem, who interpreted the output, who benefits from the conclusion, who bears the consequences of error, and what institutional procedures allow criticism. This level is essential because the most dangerous errors in digital society are often not pure mistakes in formal inference but unexamined transfers of authority: the system says, the teacher accepts; the metric ranks, the institution obeys; the platform recommends, the public follows. The fourth result is that explainability must be understood in a richer philosophical sense than mere technical transparency. It is not enough to open a model, display variables or provide a confidence score. A rational explanation must connect data, concepts, rules, values and consequences in a form that can be interrogated by competent participants. The fifth result concerns education. Logic teaching in universities should include three competencies: formal competence, which enables students to identify structures of valid and invalid inference; abductive competence, which enables them to construct and compare explanatory hypotheses; and digital-epistemic competence, which enables them to evaluate automated outputs critically. Such a curriculum would move beyond rote formulae and cultivate a culture of responsible reasoning. The sixth result is a philosophical demarcation of human judgement. Human judgement is not superior because it is infallible; humans are obviously fallible, biased and sometimes proudly irrational, which is one of our least charming traditions. Human

judgement is indispensable because responsibility, justification, dialogue and revision require a participant who can give and ask for reasons. An AI system can process signs; a rational agent must answer for meanings. This distinction does not degrade technology; it places technology in its proper role as an instrument of inquiry rather than a substitute for the normativity of reason.

DISCUSSION

The results have several implications for contemporary philosophy, logic, education and social governance. First, they require a reconsideration of the status of logic in the humanities and social sciences. Logic is often treated by students as an abstract discipline remote from life, but the digital age proves the opposite. The problem is not that people lack information; the problem is that they are overwhelmed by outputs whose inferential status is unclear. A student may ask a generative system to prepare an essay and receive a text that contains correct sentences, plausible structure and invented references. A manager may rely on a dashboard whose numerical indicators look objective but conceal questionable classifications. A citizen may encounter a political claim repeated by thousands of coordinated accounts and confuse frequency with credibility. In all these cases the central question is logical and epistemological: what follows from what, under which assumptions, and with what degree of justification? Second, the study challenges a narrow technocratic interpretation of artificial intelligence ethics. Many discussions focus on privacy, bias, safety or accountability, and these are necessary; however, they remain incomplete unless they include inferential responsibility. Bias is not only a statistical asymmetry; it is also a distortion in the movement from data to conclusion. Transparency is not only the visibility of code; it is the intelligibility of reasons. Accountability is not only legal liability; it is the capacity to answer critical questions about why a conclusion was accepted. Third, the analysis clarifies why abduction must be taught carefully. Abduction is the engine of discovery, but also the engine of conspiracy thinking when uncontrolled by evidence and alternative comparison. The same cognitive form that allows a scientist to propose a brilliant hypothesis can allow a propagandist to connect unrelated events into a seductive false explanation. The difference lies not in the mere production of a hypothesis but in the discipline of testing, comparison, defeasibility and public criticism. Artificial intelligence can intensify both sides. It can help researchers discover patterns, and it can help misinformation producers manufacture coherent-looking narratives at scale. Therefore, a mature philosophy of logic must treat abduction as both opportunity and risk. Fourth, the proposed three-level model helps reconcile formal and informal approaches to logic. Formal validity remains the backbone of rational discipline, but many socially important arguments cannot be fully captured by formal validity alone. Policy reasoning, ethical deliberation, historical explanation, educational diagnosis and philosophical interpretation involve contexts where premises are contested and concepts are evaluative. Informal logic and argumentation theory therefore do not replace formal logic; they extend

the arena in which logical norms function. Fifth, the model has institutional implications. Universities, journals, schools and public agencies should not use AI outputs without clear procedures of verification. In academic work this means that references must be checked, arguments reconstructed, premises exposed and conceptual claims evaluated. In teaching it means that students should learn to use AI as a partner for questioning, not as a warehouse of ready-made answers. In governance it means that automated decision systems must be accompanied by human review capable of understanding both technical and normative dimensions. Sixth, the analysis suggests a philosophical criterion for trustworthy digital reasoning: a digital inference is trustworthy not when it is produced by an advanced system, but when it can be reconstructed as a chain of reasons open to criticism, correction and responsible use. This criterion does not demand impossible absolute certainty. It demands disciplined fallibilism: the readiness to justify, test, revise and sometimes abandon a conclusion. Such fallibilism is close to the best traditions of scientific rationality and deeply compatible with democratic culture. A society that forgets logic does not become post-logical; it becomes pre-critical, and usually someone with a louder algorithm moves in.

PRACTICAL IMPLICATIONS AND SCIENTIFIC NOVELTY

The practical significance of the proposed model becomes visible when it is transferred from abstract theory into concrete academic and institutional procedures. In higher education, the first implication is the need to redesign logic courses around layered rationality rather than around isolated formal exercises. This does not mean weakening formal logic; on the contrary, it means protecting it from the misunderstanding that makes students treat it as a decorative algebra of letters. A modern course can begin with classical forms of validity, move to propositional and predicate structures, then examine informal fallacies, abductive hypothesis formation, probabilistic reasoning and finally the critical evaluation of digital outputs. Such sequencing would allow students to see that a valid form is not the enemy of creativity, and that an explanatory hypothesis is not a licence for intellectual improvisation without evidence. The second implication concerns academic writing and research supervision. When students or researchers use artificial intelligence in preparing summaries, literature reviews or conceptual drafts, the supervisor should not ask only whether the text is original in a technical sense. The deeper question is whether the argument can be reconstructed, whether references exist, whether concepts are used consistently, whether the conclusion follows from the evidence and whether the author can defend the position orally. This approach is more philosophically sound than the ritual of worshipping detection percentages, because a detector can indicate suspicion but it cannot replace judgement. The third implication concerns public institutions. Automated decision-support systems in education, finance, administration or media should be accompanied by protocols of inferential audit. Such an audit would ask what data were used, what assumptions defined the categories, what alternative explanations were

considered, what risks of false positive and false negative decisions exist, and which human authority can revise the result. This proposal connects logic with governance. A society governed by opaque inferences is not fully rational even if its technologies are advanced. The fourth implication concerns the training of philosophy teachers. Teachers of logic and philosophy should be able to explain not only traditional fallacies but also new digital fallacies: confusing correlation with causation because a dashboard displays a pattern; confusing fluency with truth because a generated answer sounds authoritative; confusing popularity with validity because a claim is widely shared; confusing classification with understanding because a system assigns a label; and confusing prediction with moral permission because a model estimates future behaviour. These are not entirely new errors, but digital systems give them industrial speed and aesthetic polish. The fifth implication is methodological. Researchers in philosophy should cooperate more actively with computer science, pedagogy, psychology and law, while preserving the autonomy of philosophical analysis. The role of philosophy is not to provide decorative ethical language after technical decisions have already been made; its role is to clarify the concepts by which decisions become rationally and morally assessable. The scientific novelty of the article is therefore expressed in three propositions. First, it defines digital rationality as a layered structure rather than a single capacity. Second, it interprets abduction as the mediating form between formal validity and practical uncertainty. Third, it places epistemic responsibility at the centre of artificial-intelligence-supported reasoning. This novelty can guide future empirical studies: researchers may investigate how students distinguish validity from plausibility, how teachers evaluate AI-generated arguments, or how institutions design procedures for algorithmic accountability. The model can also be adapted to professional ethics, because lawyers, doctors, engineers, journalists and administrators all face decisions where automated outputs must be interpreted under normative constraints. In each case, the philosophical demand is the same: do not outsource the burden of reasons. To use a sharp formulation, artificial intelligence can be a microscope for patterns, but it is not a conscience for conclusions.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

The limitations of the study follow from its theoretical orientation, but these limitations are also productive because they define a programme for further inquiry. The article does not claim that every artificial-intelligence system operates according to the same inferential architecture, nor does it reduce machine learning, symbolic reasoning, causal modelling and generative language systems to one technical mechanism. Its claim is philosophical: whenever a digital system is used as a source of reasons, its output enters a normative space in which validity, explanation and responsibility must be distinguished. Future research can develop this claim in several directions. One direction is empirical-pedagogical: testing how students evaluate AI-generated arguments before and after training in formal logic and abduction. Another direction is institutional: comparing how universities, journals and

public agencies define responsibility for automated outputs. A third direction is technical-philosophical: analysing how explainable AI methods correspond, or fail to correspond, to philosophical standards of explanation. A fourth direction is regional and cultural: studying how traditions of philosophical education in Central Asia can integrate digital epistemology without losing their humanistic orientation. These directions would move the model from conceptual proposal to applied research. They would also prevent a common error: treating digital reason either as a miracle beyond criticism or as a threat beyond use. Serious philosophy should avoid both melodrama and worship.

CONCLUSION

The article has argued that the digital transformation of reasoning requires a renewed philosophical understanding of logic. Logical validity, abductive reasoning and epistemic responsibility are not isolated topics; they form a single normative architecture of rational life in artificial-intelligence-mediated society. Formal validity protects thought from contradiction and invalid consequence; abduction enables inquiry under uncertainty by generating explanatory hypotheses; epistemic responsibility ensures that conclusions remain answerable to persons, institutions and communities of criticism. The study's main scientific contribution is the three-level model of digital rationality, which distinguishes and connects these dimensions. This model demonstrates why artificial intelligence should be integrated into reasoning practices without surrendering the human duty of justification. The conclusion is not anti-technological. On the contrary, the best use of AI requires stronger, not weaker, logical culture. When algorithms expand the speed and scale of inference, philosophy must expand the depth and responsibility of interpretation. For university education, especially in philosophy and logic, this means that curricula should teach formal inference, abductive hypothesis evaluation and digital epistemic responsibility as mutually reinforcing competencies. For research and public institutions, it means that automated outputs should be treated as materials for rational examination, not as final authorities. In the long perspective, the future of logic is not threatened by artificial intelligence; it is threatened by the human temptation to confuse convenience with justification. A rational digital society will be one in which machines calculate, models predict, systems assist, but persons and institutions still give reasons. That is not a nostalgic defence of the past; it is the minimum condition for a future in which intelligence remains accountable.

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